

From water footprint to climate change adaptation: Capacity development with teenagers to save water



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ABSTRACT

This article presents a bottom-up approach which attempts to link the Water Footprint (WF) concept with climate change adaptation and capacity development. The approach was developed and tested in cooperation with a partner school in Austria aiming to provide a starting point for WF assessment and formulate an improvement response. The pupils reduced their WF by 9%, and became change agents. The approach assists young people to develop self-efficacy by discovering the connection between their individual actions at local level and aspects of climate change adaptation at global level. It provides a tool to increase this understanding and contribute to the adaptation of distant impacts of climate change and reduce vulnerability.

1. Introduction

The water sector will be significantly affected by climate change (IPCC, 2013). In particular, the trend of ever increasing water demand has a significant impact on the quantity and quality of water available at local and global scales (IPCC, 2014a; United Nations, 2015b; UNWWAP, 2015). As emphasised by the UNs Sustainable Development Goal “Clean Water” (United Nations, 2015b), an urgent need to adapt freshwater management and policies to these changes has been identified (European Environmental Agency, 2015; Haida et al., 2017). Complementing mitigation efforts, many global and national climate change policies have adopted climate change adaptation strategies (European Commission, 2013, IPCC, 2014a, 2014b) to prevent or minimise possible negative effects and to enhance opportunities. This is ever more important also in light of the ambitious targets set during COP21 in Paris (United Nations, 2015a). Enhancing capacity building has been agreed on as one of many actions to strengthen the abilities of countries to respond to climate change impacts. Together with Education for Sustainable Development (UNESCO, 2017) these two toolkits are essential for achieving the COP21 targets, in particular awareness building regarding trans-regional responsibility is vital (Haida, 2016).

Developing and implementing successful adaptation measures in freshwater management should involve local stakeholders, integrate numerous policy areas (e.g. regional development and water management) and apply low-regret measures and bottom-up processes. The water footprint (WF) concept helps to reduce global water consumption and thus provides a tool to adapt to the impacts climate change has on water by communicating, assessing and improving the WF (Chapagain et al., 2006).

According to Hoekstra et al. (2011) the WF is an indicator of fresh water use which includes both the direct and the indirect water use of a consumer or a product, also defined as the direct WF and the indirect WF, respectively. This can be calculated for a specific product, process, person or region and generally consists of the three components: blue, green and grey WF (c.f. Hoekstra et al., 2011). The green water footprint refers to the total precipitation or soil moisture held in the unsaturated and is available to plants, while the blue water footprint is an indicator of the amount of fresh surface or groundwater consumed in producing goods and services. The grey water footprint is a measure of pollution and is expressed as the volume of water required to assimilate the pollutant load to meet ambient water quality standards.

Direct WF accounts for the direct consumption and pollution of

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fresh water caused by activities such as domestic water use for a person, operational water use in factories or businesses, and the use of internal national water resources for a country. The indirect WF is based on the concept of virtual water (Allan, 2003) and thus does not only account for the amount of water physically contained in a product, but also includes the amount of water, which is used during the entire production process. By trading water intensive products, a country or a region creates “virtual water flows”. These can be instrumental in relieving the pressure on the internal water resources of a region, whilst creating dependencies on external water resources and vice versa (Chapagain and Hoekstra, 2008).

WF assessments have been suggested to be an effective means of raising awareness of global water challenges among stakeholders outside the water policy sector (Chapagain and Tickner, 2012). Although efficient water use is essential for sustainable water use, a focus must also be made on the equitable and fair distribution of this limited resource. Therefore, there is an urgent need to evaluate the sustainability of current consumption patterns in the light of a growing world population and the limited freshwater resources (Hoekstra, 2013). Under climate change conditions, fresh water availability will decrease and become more unevenly distributed across the globe (IPCC, 2014a), whilst socioeconomic developments and population growth are predicted to increase the demand for water (UNWWAP, 2015; Wang et al., 2016). For example, under a moderate to low population growth scenario from the UN, the fresh water availability in 2050 will be 835–1045 m³/year/capita. This, however, is exceeded by current water demand, with a global average WF of 1385 m³/year/capita, ranging between 1250–2850 m³/year/capita in industrialized countries and 550–3800 m³/year/capita in developing countries (Hoekstra and Mekonnen, 2012).

The production of agricultural products is responsible for 70% of the total blue water withdrawals from aquifers, lakes and rivers (UNWWAP, 2015). Furthermore, adding the green and grey WF components to the blue WF for food production, more than 90% of the global average WF is related to food consumption (Hoekstra and Mekonnen, 2012). Focusing on the food sector there are various levels and leverage points to reduce the WF and make it more sustainable:

- policy level: increasing the volume of food which is traded through efficient trade relationships (Dalin et al., 2012) by encouraging an export of agricultural goods produced in water rich and water efficient regions to water scarce and less efficient regions considering other limited resources can result in a smaller usage of water per produced amount of crop and can save ~6% of water used in agriculture (Chapagain et al., 2006).
- producer level: increasing water productivity (i.e. the inverse of the virtual water content per product) of agricultural products and industrial processes (Vanham and Bidoglio, 2013),
- consumer level: changing peoples' diet, for example reducing consumption of animal products (especially meat) has a large impact on the WF, as app. 50% of cereal production (in the EU) is used as fodder for animals (Vanham et al., 2013),
- all levels: reducing food losses (producer level) and food wastes (consumer level) along the entire food supply chain (Vanham and Bidoglio, 2013; Vanham et al., 2015); increasing awareness concerning the relation between a person's behaviour and the WF, and the supply and demonstration of methods to reduce the WF.

This demonstrates that good water governance requires a sharing of responsibility between consumers, governments, businesses and investors, with each playing different roles (Hoekstra, 2013). Consumers, however, are the biggest drivers and offer the greatest leverage for adaptation, as they are the key for the three remaining actors to change.

To date, the WF concept has mainly been used to calculate the WF of a product, a company or nation, illustrating virtual water flows, connecting these with climate change scenarios and deriving potential

water saving strategies (Hoekstra and Chapagain, 2007; Chapagain and Hoekstra, 2008; Mekonnen and Hoekstra, 2011; Orlowsky et al., 2014). However, little work has been done to actually implement water saving strategies by applying the WF at the consumer level. To do so, a suitable approach is needed, which conducts bottom-up climate change adaptation by linking climate change with the WF. To achieve this, capacity development provides a suitable framework to encourage stakeholders to adapt and reduce their WF to sustainable limits. According to UNDP (2008, p. 4) capacity development is defined as “the process through which individuals, organizations and societies obtain, strengthen and maintain the capabilities to set and achieve their own development objectives over time”.

In this context, a successful WF adaptation approach needs to be sustainable, participative, long-term oriented, should have a multiplier effect and the outcomes need to be evaluated. Based on these requirements, this article presents an innovative bottom-up approach to improve the personal WF. By linking the WF concept with climate change adaptation and capacity development this novel approach provides a tool to empower individuals within their capabilities to contribute to the adaptation to the impacts of climate change. The objectives of this approach are to i) create awareness among young people regarding their water consumption habits and the consequences, ii) relate the complex issue of global water management to personal consumption habits and thereby facilitate the development of self-efficacy among young people, iii) link global climate change impacts with local water consumption, and iv) empower young people to use their capabilities to take action in adapting to climate change. Thereby, furthering the UNs Sustainable Development Goal “Climate Action” (United Nations, 2015b), this approach assists in responding to and preparing for climate change impacts on fresh water on the global scale and thus provides a valuable tool. The aim of this article is to describe this approach, followed by its practical implementation and evaluation in a regional case study.

2. Water footprint adaptation approach

2.1. Theoretical background and concepts relevant for the approach

Although the development of the water footprint approach is based on various theoretical backgrounds, there are three particular theoretical domains which played a crucial role in the development and implementation of the approach at hand. The increasingly growing field of research and practice linked to Climate Change Education (CCE) provides insights about enhancing the understanding of climate change and its consequences and preparing current and future generations to respond to its challenges by developing their competencies and increasing critical engagement, thus empowering individuals to deal with the complexity of it (Beatty, 2012). In addition to being aware of the disengaging impact of conveying “doom-and-gloom” messages about climate change, scientists argue for a politically and psychologically smart (Ockwell et al., 2009) creation of positive visions, however, respecting acknowledged success factors (Nisbet, 2009; O'Neill and Nicholson-Cole, 2009; Moser, 2010; Spence and Pidgeon, 2010; Wolf and Moser, 2011; Corner et al., 2014). In contrast to the longstanding misconception in Environmental Psychology research about educating the public about climate change to correct an “information deficit”, it is one of the key insights of CCE that social norms and personal values, emotions and experiences are much more important than knowledge as such (Marx et al., 2007; Moser, 2010; Vulturius et al., 2016). Latest research from policy experts suggests that “knowing your audience”, “setting clear, realistic goals”, “not trying to scare people into action”, “earning and maintaining trust”, “recognizing the importance of values and social norms” and “not expecting to win every time” are key success factors of CCE.

In addition to CCE, transdisciplinary knowledge production offers a highly relevant theoretical field as a fundament for the development

and implementation of the approach. According to Pohl and Hirsch Hadorn (2008) knowledge produced in transdisciplinary processes can be categorised as system, target, and transformation knowledge. In the context of transdisciplinary sustainability research, it can be distinguished between “knowledge concerning the current situation” (systems knowledge), “knowledge concerning the target situation” (target knowledge) and “knowledge about shaping the transition from the current to the target situation” (transformation knowledge). Despite their strong connection, these three different forms of knowledge follow different objectives. While research questions about the genesis and possible further development of climate change and its interpretations in the lifeworld aim at the production of systems knowledge, research questions related to determining and explaining the need for change, desired goals and better practices rather aim at the production of target knowledge. In addition to these two “more academic” forms of knowledge, research questions about technical, social, legal, cultural and other possible means of acting that pursue to transform existing practices and introduce desired ones, aim at the production of transformation knowledge (Frischknecht and Schmied, 2003; Pohl and Hirsch Hadorn, 2008).

While the aforementioned state of the art depicts a relevant theoretical fundament that is to be considered, it requires an actual learning theory compatible to these insights and concepts as well as suitable to implement the theories in practice. The learning theory of moderate constructivism derived from the epistemology of constructivism and has increasingly influences didactics since the 1970s. In a moderate constructivist understanding, learning is seen as a process that is individually constructed, self-determined, social and situated (Kattmann, 2003; Mandl, 2006). Constructivism is a psychological and philosophical perspective, in which individuals form or construct much of what they learn and understand based on their prior learning, knowledge and social interaction (Brooks and Brooks, 1999). Hence, in a constructivist learning process, learners adopt the role of seekers and problem solvers; produce their own products by searching, taking decisions, collaborating, using high level analytical skills and their individual creativity (Dunlap and Grabinger, 1996; Demirel, 2005).

Recent empirical research has shown that moderate-constructivist learning settings taking into account CCE success factors can be particularly effective frameworks for empowering young people in the context of climate change challenges (Riede, 2016).

2.2. Set up of the approach

The Water Footprint Adaptation Approach incorporates the above described concepts and follows the common process of capacity development (UNDP, 2008). The approach (Fig. 1) includes five sequential phases, which pursue an iterative process of design-application-learning adjustment, and incorporates current methods of climate change communication. The WF adaptation approach was designed to address young people, since they will be affected longer and more intensively by climate change and are in a stage of life in which fundamental values are developed; additionally, today's children and teenagers will be the leading decision makers in the future. Empowerment through education has strong effects on reducing vulnerability to climate change and enhancing adaptive capacity (Lutz et al., 2014). Therefore, it is necessary to empower and integrate young people in the debate about climate change and sustainability of WFs as early as possible.

The first phase of the WF adaptation approach aims to engage and introduce the relevant stakeholders, in this case young people, to the topic, by outlining the connection of the participants' personal water consumption (and their WF) to climate change (adaptation). This is of high importance since for young people climate change is fundamentally about the “here and now” (Corner et al., 2014). In this phase, predominantly system knowledge (Pohl and Hirsch Hadorn, 2008) will be imparted. This includes climate change impacts on water



Fig. 1. Water Footprint adaptation approach.

availability, fundamental knowledge about the WF and WF of different products and activities (e.g. food, clothes, shower, washing up etc.). Linking water consumption of the “here and now” with consequences on the other side of the world, illustrates how an improved and reduced WF relieves water stress elsewhere, and thus communicating WF as a tool to adapt to the impacts of climate change.

The second phase aims to monitor the individual water consumption, to assess the personal WF and to identify improvement potential. The data collection may not necessarily focus on the calculation of an exact WF but rather on providing a starting point to reflect the personal WF and thus to be able to formulate a capacity development response (UNDP, 2008). In general, people perceive climate change (impacts) as a menace to flora, fauna and people in other parts of the world, but do not see it as a local issue (Center for Research on Environmental Decisions, 2009). Furthermore, individuals often feel that their own actions have little impact and have little control over the effect of climate change (Payne, 2013). Therefore, developing self-efficacy among the participants is particularly emphasized in this phase, by training them to use the WF concept as a tool to adapt to climate change.

Although fearful representations (of climate change) have much potential for attracting people's attention, fear in general is an ineffective tool to motivate genuine personal engagement (O'Neill and Nicholson-Cole, 2009; Moser, 2010). Therefore, phase three builds on the potential for improvement, and initiates a co-developing process of WF improvement measures between scientists, practitioners and young people. Throughout the entire approach, but specifically in phase two and three, a moderate-constructivist understanding of learning is pursued (Riemeier, 2007). Thereby young people develop ownership of the particular measures and they are more likely to be able to reduce their WF. During these phases pupils acquire the necessary target knowledge (i.e. what are the sustainable limits of the personal WF) and transformation knowledge (i.e. how can behavioural patterns be overcome to ensure that these limits are not exceeded) to utilize their WF to adapt to climate change via improving their WF (Pohl and Hirsch Hadorn, 2008).

In phase four, participants implement the measures which have been developed in cooperation with scientists and practitioners. On the one hand, they attempt to implement the measures individually and on the other hand, they also try to convince as many others as possible to also participate. Thereby, the approach makes use of existing evidence to empower children and teenagers as change agents within their communities (Mitchell et al., 2008; Tanner et al., 2009; Haynes et al., 2010; Tanner, 2010).

The fifth and final phase, evaluates the effectiveness of the WF

adaptation approach (Noble et al., 2014) on both the cognitive and the behavioural levels (Preston et al., 2011; Sanahuja, 2011; Riede et al., 2017). The cognitive evaluation assesses the lessons learned, the usefulness and applicability of the capacity development. To evaluate potential behavioural changes, the personal WF of the participants is monitored and assessed a second time. Such a pre-intervention and post-intervention comparison of WFs in combination with the cognitive evaluation provides insights into the impact and efficacy of the entire approach.

3. Application of the approach

3.1. Case study set up

Austria with its Alpine landscape is often regarded as a water tower, which supplies fresh water to neighbouring countries. However, Austria is actually a net importer of virtual water often with imports from water scarce regions, such as Spain, or regions which experience severe environmental problems from agricultural intensification, such as Argentina or Uzbekistan (Vanham, 2012). Some of these locations where the external WF of Austria is located, are exposed to the risk of less water availability and associated vulnerabilities due to changing precipitation patterns under climate change scenarios and these links of virtual water flows might not be sustainable (Konar et al., 2013). This emphasises the urgent need to adapt water consumption also in regions which do not directly experience water stress or scarcity. For these reasons Austria was selected, and a pilot study carried out with a partner school in Innsbruck, with whom this approach was developed and implemented. Two classes from one school participated in the study, which included four sequential workshops, each lasting two hours. In total 38 pupils, aged 16–18 years, took part in all activities running over 1.5 years in 2013–2014.

3.2. Methods

The four workshops corresponded with the five previously described phases.

In the 1st workshop the pupils acquired necessary system knowledge in order to engage them with the topic and were trained to assess their personal WF. To monitor and subsequently calculate their WF before the intervention, the pupils used a check list. This list was specifically designed to be practical and feasible for use in daily life and contained 21 different water consumption categories (Table 1).

The categories were limited to those that use the most water and in sum amount to almost the complete daily water consumption. Over a period of 28 days in autumn 38 pupils marked every consumed unit per category on a weekly basis. In order to get the entire family involved and so to reach more people, the families' consumption was included in the monitoring as well. The monitoring was limited to the water consumption which took place at home, as it was not practicable for the pupils to track down the entire consumption of every family member during the day when they were not at home. The check list included also additional information, such as number of people living in the same household, existing garden and size, existing swimming pool and size.

Based on this monitoring data the pupils calculated their personal WF as:

$$WF_{pers,ID} = cons_{ID} \times V_{ID} \times d^{-1} \times p^{-1} \text{ [Litre/Capita/Day]}$$

$$WF_{pers} = \sum_{ID} WF_{pers,ID}$$

where $cons_{ID}$ refers to the sum of consumption marks per water consumption category on the check list, V_{ID} to the water volume used per consumption in Table 1, d to the amount of days the monitoring took place, and p to the number of people living in the household. The WF

Table 1

Water consumption categories which were monitored by 38 pupils and marked per consumption unit. The volume per consumption category of direct water use (abstraction) is based on Neunteufel et al., 2012, where it was assumed that one unit of direct water use equals one unit direct water footprint. Indirect water volumes are based on Mekonnen and Hoekstra (2011) and Mekonnen and Hoekstra (2013).

ID		Consumption unit	Volume per consumption [L]
<i>Direct water</i>			
1	Washing machine younger 5y.	per use	44
2	Washing machine older 5y.	per use	100
3	Dish-washer younger 5y.	per use	16
4	Dish-washer older 5y.	per use	50
5	Dishes hand	per use	35
6	Brushing teeth water running	per use	1.7
7	Brushing teeth water turned off	per use	5.2
8	WC eco-button	per use	3
9	WC normal button	per use	7
10	Showers	per use	36
11	Baths	per use	76
12	Car washed	per use	100
<i>Indirect water</i>			
13	Coffee	cup	132
14	Tea	cup	27
15	Dairy products	kg	1675
16	Eggs	piece	196
17	Fruits	kg	1000
18	Vegetables	kg	300
19	Meat	kg	7220
20	Cereal products	kg	1600
21	Jeans cloths	per piece at home	8000

results were presented and discussed in a 2nd workshop. The calculation of the personal WF was not designed to differentiate between green, blue and grey water, as this would have required additional information on the food products consumed, such as the exact origin of the production, and was considered as not feasible for the pupils. However, the breakdown into the green, blue and grey WF of produce was part of the discussion in the 2nd workshop and was considered in the process of developing improvement strategies in workshop 3.

To develop WF improvement strategies and measures the pupils worked in small focus groups in a 3rd workshop. The aim was to develop and define concrete measures for each individual to improve their personal WF. Out of these, every pupil chose 2–3 measures and implemented them for 6 weeks. 36 of the pupils recorded their improvement measures.

In addition to the WF assessments, a general evaluation about the pupils' experiences with the approach took place in a 4th workshop. By means of individual questionnaires the pupils were asked to rate the contribution of each of their implemented measures to reduce their WF (high, small, none) and whether it was easy or difficult to implement their measures. To evaluate the long-term and more sustainable behavioural changes, in addition to the first WF monitoring period (pre-intervention WF assessment), a second monitoring (post-intervention) took place one year later, following the same method. Shorter term behavioural changes were not considered relevant for the purposes of achieving sustainable climate change adaptation and so no monitoring was done directly after the intervention period. For this second monitoring over one week 38 pupils monitored their water consumption, however, only 31 of the records were found suitable to be used and hence were analysed.

4. Results

The total WF of the pre-intervention monitoring was 1965 L/C/D,

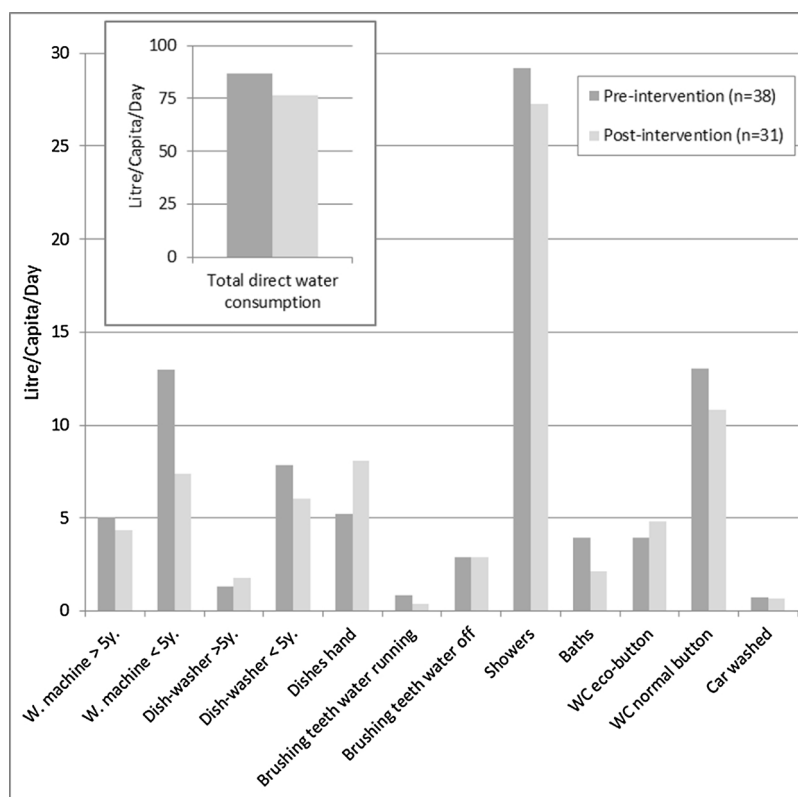


Fig. 2. Direct water footprint comparison before and after the intervention. Water consumption categories are listed in Table 1.

with the weekly WF ranging between $\pm 2.6\%$. Due to this narrow range, the post-intervention monitoring was shortened to only one week.

Before the intervention the pupils had an average direct WF_{pers} of 86.6 L/C/D, which they were able to reduce by -11.9% (Fig. 2). Showers (ID10) accounted for the highest water consumption before and after the intervention. The WF of using older washing machines (ID2) was reduced by -43% . Also the use of older dish washers (ID4) could be reduced by 23%, which was caused by some families who instead washed their dishes by hand. Another trade-off was discernible from changing from using the normal toilet button (ID9) to instead using the eco-button (ID8) more often.

The total indirect WF_{pers} could be reduced by -9.2% from 1879 L/C/D to 1,706 L/C/D (Fig. 3). This was mainly caused by a reduced consumption of dairy products (-44% ; ID17) and cereal products (-32% ; ID19). Consumption of meat products (ID20) accounted for the highest consumption before and after the intervention and was the only category which increased notably by $+95$ L/C/D ($+12.1\%$) in the post-intervention phase.

The reduction of the total WF_{pers} could be achieved through 16 different improvement measures, which were developed and implemented by the pupils (Table 2). The majority (52.8%) of the pupils chose to reduce their meat consumption. The reduction rates ranged from a general “eat less meat” to “eat meat only once per week”. This was followed by re-using PET bottles (47.2%) and having shorter showers (41.7%). In total the pupils chose from 10 measures which reduced the indirect WF and from six measures which addressed direct WF. Although these measures were implemented for only six weeks, they seemed to have a longer lasting effect on their water consumption behaviour, as the post-intervention WF_{pers} assessment was 8 months after the implementation period.

Although the pupils knew about the high WF of meat products and the majority chose to reduce their meat consumption, the comparison of the pre- and post-intervention showed a notable increase. Evaluating

the WF improvement measures, 56% of the pupils confirmed that this measure was particularly difficult to be applied. This might be the reason why 50% also rated it as being hardly effective. This shows that the willingness to change consumption behaviour highly depends on personal preferences and could result in lack of confidence in the effectiveness. Moreover, young people often have limited control over their food consumption, as they are embedded in the family background.

In addition to these measures, the pupils collectively articulated the urgent desire to further spread the idea of saving water via adjusting the WF_{pers} , which resulted in organising a so called “water week” at their school. The aim of the “water week” was to raise awareness amongst their fellow pupils. This indicates that the students presumably developed a certain sense of self-efficacy and as they acted as change agents by (voluntarily) organising and running an information desk at their school for one week. Here their fellow pupils had the possibility to get involved in various water related issues e.g. assessing their WF and water saving options. Such a follow up campaign proved to be beneficial as additionally 214 pupils (810 people if the family members are included) were convinced to measure their WF for one week, using the same method.

5. Discussion

To interpret the WF and formulate an appropriate response, Hoekstra et al. (2011) recommended a sustainability analysis by comparing the size of the WF with respect to environmental, social and economic issues. The sustainability of WFs can be evaluated regarding two criteria. In case of process efficiency, comparing benchmark values of similar processes and activities under similar conditions is one option. Another option is a geographic hotspot check, which examines if the collective WF of all users which are located within the same river basin does not exceed the sustainable limits regarding quantity and quality. In the case of products, such as crops, there are some global

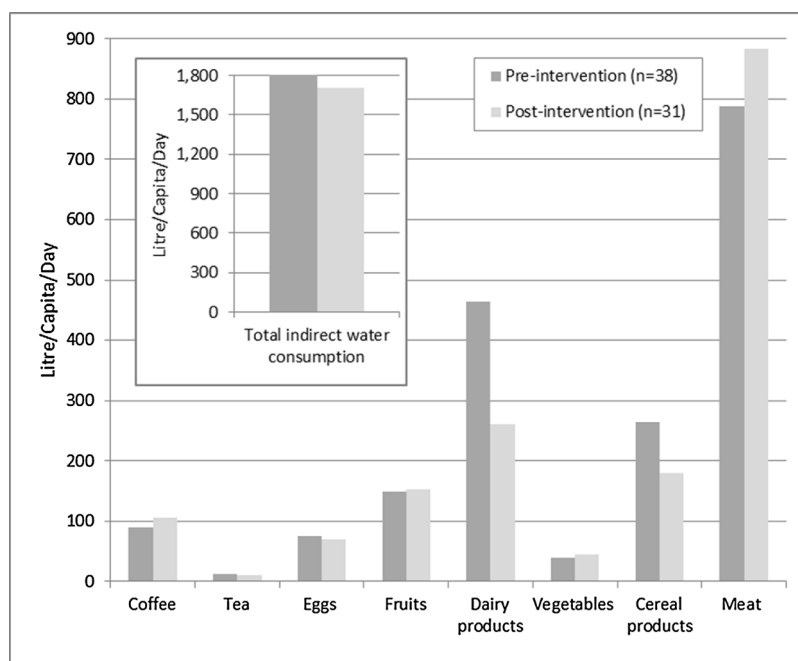


Fig. 3. The indirect water footprint comparison before and after the intervention. Water consumption categories are listed in Table 1.

Table 2

Measures which were implemented over 6 weeks, with the number of students who implemented each of the measures.

Measure	Number of students	Students [%]	WF type
Eat less meat	19	52.8	Indirect
Re-use PET bottles	17	47.2	Indirect
Shorter shower	15	41.7	Direct
Turning of tap	7	19.4	Direct
Eco button (toilet)	7	19.4	Direct
Tea instead of coffee/less coffee	7	19.4	Indirect
Shower instead of bath	6	16.7	Direct
More regional/seasonal products	6	16.7	Indirect
Separating waste	5	13.9	Indirect
Only full loads with dish washer/washing machine	3	8.3	Direct
Tap water instead of bottled water	2	5.6	Indirect
Use more public transport	2	5.6	Indirect
Airing clothes instead of washing	1	2.8	Direct
More organic products	1	2.8	Indirect
No new clothes in the next six weeks	1	2.8	Indirect
Cloth bag instead of plastic bag	1	2.8	Indirect
“Water week”	36	100	Both

benchmark values available (Mekonnen and Hoekstra, 2013). This is certainly a way forward on a regional or national basis for agricultural or industrial products or production processes. However, benchmarking of personal WFs demands complex assessments, which also include the socio-cultural context, assessment methods, data used, study aim, etc. A simple comparison of the total WF value from this study (1965 L/C/D) with the WF calculated by Vanham (2012) for Austria (4377 L/C/D) shows this discrepancy. Reasons for these different WF are the quantities of food consumption and the varying product groups considered in the WF calculation. This could be caused by unreliable reporting of the pupils' own consumption and in particular that of their family members. However, as it was not the aim of this study to calculate an exact WF, instead it might be more reasonable to relate the WF to other data on the basis of the separate components of the WF or the underlying consumption pattern.

For Austria, this was possible by using Neunteufel et al. (2012)

regarding the direct WF and using Statistik Austria (2011) and FAOSTAT (2009) regarding the indirect WF. Although the pupils' WF was generally slightly lower, the pupils' consumption pattern matched well with the statistical data. Differences were mainly caused by less use of toilets and less coffee consumed. This was a result of the limitation of water consumption to water that was consumed only at home and the generally lower average age of the case study participants, respectively. In addition, the monitored categories did not encompass all water related uses but only the most significant ones. Regardless of exactly what data is used to relate the WF to, it is more important to formulate a response, which is backed by all participants. To achieve this, the bottom-up approach proved to be effective and the participants were able to improve their WF.

To further refine the WF improvement, distinguishing between green, blue and grey water has been suggested (Hoekstra et al., 2011). This is a viable approach when addressing commodity flows and agricultural processes; however on the consumer level, like in this case study, this might not be a very useful concept. Reasons are that on the one hand consumers have little to no knowledge or information on the different water components in their consumed products and on the other hand sustainability labels, which indicate this information, have proved to be of little motivation for consumers to choose their products appropriately (Grunert et al., 2014). On the producer level, however, increasing the WF knowledge of their products might be helpful to increase the water productivity (Wang et al., 2014). In this case, bottom-up approaches such as capacity development are essential (Kijne et al., 2009) and combined with institutional top-down approaches, such as financial incentives, this might lead to widely accepted improvements. While not directly transferable, the WF adaptation approach developed herein might serve as a role model also for bottom-up approaches at the production side of water intensive goods.

In this case study the consumption of food accounted for the largest part of the personal WF, with the consumption of meat products contributing in particular. This consumption pattern matched well with records on the Austrian nutritional status (Elmadfa, 2012). In relation to the remaining food groups which were monitored, the amount of daily meat consumption exceeded recommendations of a general healthy nutrition by DACH (2000) more than twofold. Changes in the diet, with a shift from a meat dominated nutrition to a healthier more

balanced diet have been suggested to improve the WF substantially (Vanham, 2013; Vanham et al., 2013; Ercin and Hoekstra, 2014). In this context, the presented approach helps to communicate and to promote a healthier diet, thus contributes to a sustainable supply of food and advances the SDGs “Zero Hunger”, “Good Health and Well-being” and “Responsible Consumption” (United Nations, 2015b).

6. Conclusion

This study implemented and evaluated a tool in the form of an innovative participatory approach to improve the personal WF by linking climate change adaptation with the WF concept and capacity development, by means of a bottom-up workshop cycle. Illustrating the complexity of this challenge, the approach encompasses and contributes to several policies and frameworks, such as:

- Paris agreement targets (United Nations, 2015a)
- United Nations Sustainable Development Goals (United Nations, 2015b)
- Education for Sustainable Development (UNESCO, 2017)
- European and National climate change strategies (European Commission, 2013; APCC, 2014; BMLFUW, 2017)

In particular it provides a new tool for implementing capacity-building, which has been identified by the Paris Committee on Capacity-building as one central activity in order to assist countries in their climate actions (United Nations, 2015a).

The evaluation of the implementation proved the approach to be efficient, considering that with comparably moderate financial efforts, the awareness of the pupils on the matter could be increased and a measurable reduction of the personal WF achieved. The fact that the pupils expressed the desire to act as multipliers and disseminate the WF concept and water saving measures not only among their own families, but also among another 214 pupils (810 people including their family members) indicates that the approach lead to the development of intrinsic motivation and self-efficacy. This shows that with little technological effort, water saving measures can be implemented by fostering capacity development. Promoting the WF via capacity development and education for sustainable development contributes to facilitating rethinking consumerism regarding water intensive products, reducing meat consumption and thus providing for a healthier diet and reducing the waste of direct water at home. This transformation is likely to foster acceptance of complementary top-down measures.

Although the WF adaptation approach achieved remarkable improvements, some unanswered questions remain, such as: how exactly does the improvement of the WF in the “here and now” affect water resource management in other parts of the world considering climate change impacts? To better connect the “here” with the “there” it could be helpful to personalize virtual water flows on the basis of local consumption and behavioural pattern. Such personalized virtual water flows, similar to national virtual water flows (Chapagain and Hoekstra, 2008), might demonstrate the links from the location where the personal WF is produced to where the WF is consumed. Connecting the personal WF production site with local climate scenarios, in a second step, could help to illustrate the far-reaching impacts of one’s own activities. Following the general set up of the WF adaptation approach, it would then be prudent to formulate a capacity development response, focusing on WF improvement measures, which are applicable for consumers. To do so, however, more research is needed to comprehensively elucidate the impacts these measures would have on the production site. In the light of the complexity of climate change and sustainability and due to the uncertainties also involved in presumably less-water intensive behaviour, pupils participating in such an approach should be made aware of the importance of constantly questioning and rethinking their actions instead of longing for a short-term change. Therefore, from an education point-of-view the result that pupils articulated their

interest in motivating others can be seen as a bigger success than the factual WF reduction of 9%.

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